Synopsis for Registration as a Research Student for Doctoral Degree

On

Multimodal Image Registration in Remote Sensing

By

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1. Introduction

In the process of image registration two or more images of the same scene are overlayed. The first image is a reference and the second is the input image(s). Image registration uses are not only limited to the applications computer vision domain but also in the medical, satellite image, architecture etc. Image Registration classified on the basis of type of images:

1. Multi-Temporal: Registering image which differs over the time of the same scene. This registration type is used in applications where change detection or analysis is the main task. For example change of tumor size overtime in medical images, forest observation over time, and disaster analysis in satellite images

2. Multi-view: It registers the images of the scene taken from unlike angles, and sides. In architecture, it help to obtain 3D reconstruction from 2D images.

3. Multimodal: It includes the image of different modalities i.e. sensors. It is used in medical, remote sensing and computer vision applications. As the availability of the data taken from different sensors increased, multimodal image registration techniques also increased.

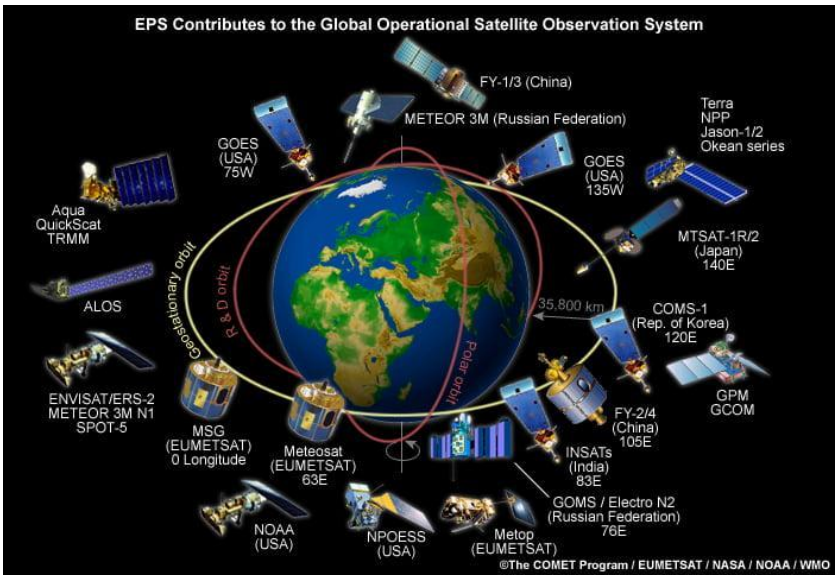

Fig. 1: The current global satellite used in remote sensing.

Fig. 1 shows a few satellites that are currently in space for applications such as weather forecasting, agriculture, ozone monitoring, air and water quality [1], etc. In remote sensing, images are acquired at different spectral regions or by different sensors. Images taken from satellites are in electro-magnetic spectrums for example, synthetic aperture radar (SAR), infrared Optical, and light detection and ranging (LiDAR). Image

registration combines these modalities provides extra information. For example, optical images provide data of the earth taken from satellites but do not provide data if there is the existence of a cloud. SAR images can penetrate from the cloud. Overlaying optical-SAR satellite images helps in the analysis of floods on rainy days, regions covered by clouds, and many small but important details. For multimodal image registration intensity-based [11], feature-based [11], and deep learning-based algorithms [4] are used.

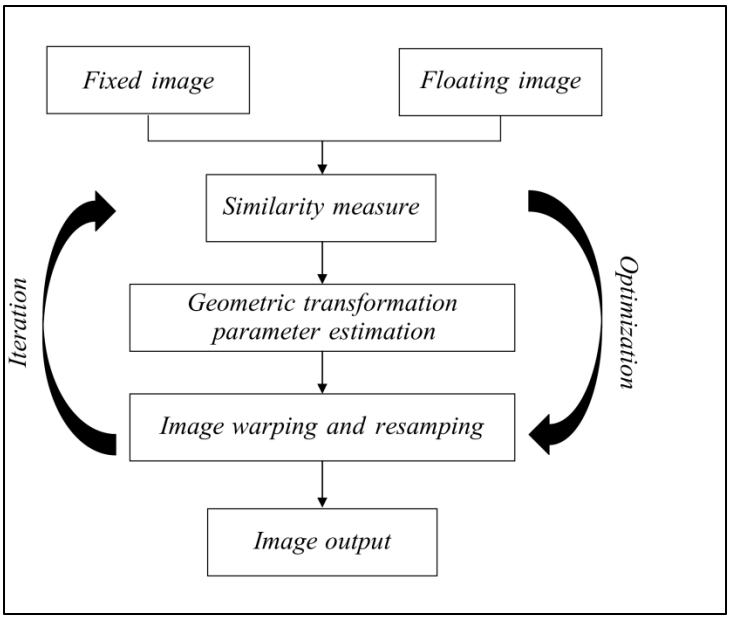

Fig. 2: Intensity-based image registration.

The intensity-based method is illustrated in Figure 2. It is consist of three fixed and floating image as input, similarity measures, geometric transformation models, and optimizations model and finally output image [11].

Feature-based image registration consist of feature detection, which picks the prominent features present in the input images, such as point and region features [11]. Next step is, feature description. It describe the extracted features for the image matching and last step is feature matching, which prepares a similarity measure for the descriptor to build a geometric transformation, to realize the alignment and registration between images. Figure 3 shows the feature-based structure.

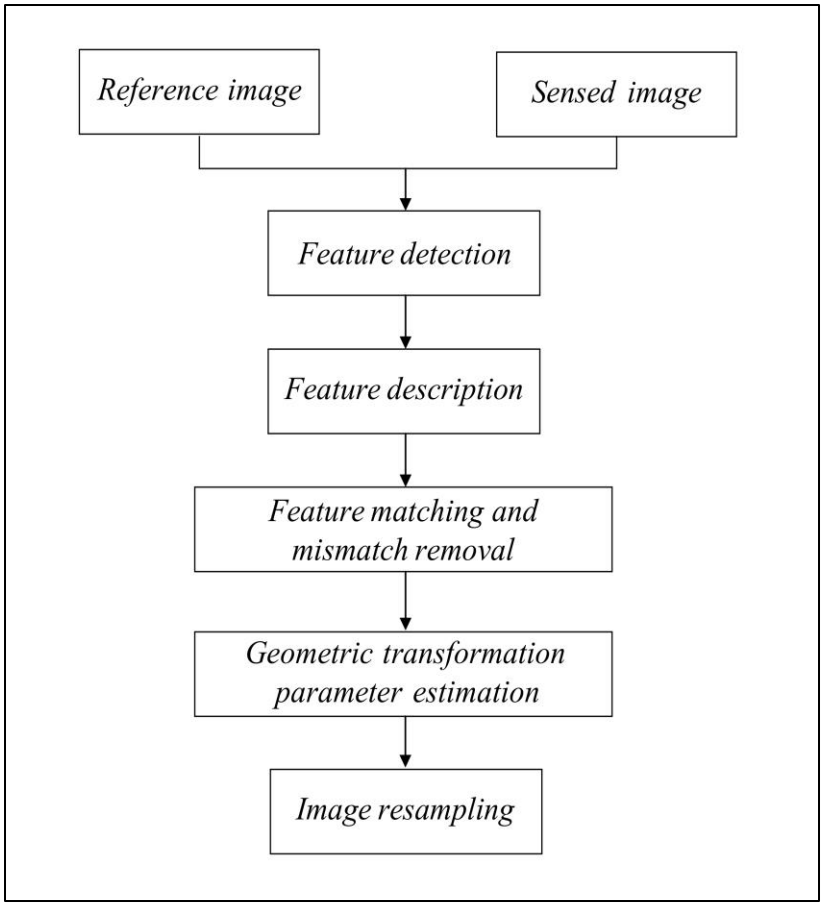

Fig 3: General structure of feature based image registration.

2. Motivation

Multimodal image registration provides the complementary information obtained from overlaying the images of different properties. Multimodality registration is specially used in the medical field such as registration of CT and MRI [6]. Much research has been done in the medical field but limited to remote sensing applications. Algorithms used in medical image registration cannot be applied to remote sensing applications. Intensity-based multimodal registration does not provide good output. It uses the similarity of the intensity values for registration.

Deep learning-based are used for image registration [8], but the ground truth available is very limited. Feature-based algorithms are also useful and require more distinct features in multimodality. So, multimodality registration can be applied for various applications for complementary information. There is also scope for improvement in the registration algorithm. As the popularity of multimodal image registration increases, a robust image registration technique is needed which can handle images of different modality, different resolution, and different spectral resolution.

3. Literature Survey

Rowley et al. (2023) proposed a model to predicting air quality using multimodal Artificial intelligence and satellite image. It predicts the quality of air by predicting the amount of NO2, O3, and PM10. For that, it uses multispectral satellite images from sentinel-2 satellite, low-resolution satellite sentinel-5P satellite, and ground truth.

Bin et al. (2023) used multi-objective optimization for the registration of visible and thermal. It uses both angular and linear aspects, to get the affine parameters.

Ye et al (2022) proposed a multimodal remote sensing image registration method. It used steerable filters with first- and second-order gradients. It registers images using two methods 1. Steerable filters of first and second-order channels are used to solve nonlinear radiometric differences, detect control points, and 2. For similarity measure Normalized Cross-Correlation (Fast-NCCSFOC) is used.

Hughes et al. (2020) proposed a deep-learning framework for matching SAR-Optical imagery. It uses a combination of goodness network (GN), correspondence Network (CN), and outlier Reduction Network (ORN) to match SAR images with Optical images.

Yang et al. (2018) proposed method for Registration of Multi-Temporal Image Using Deep Convolutional Features. It used a feature-based multi-temporal image registration method with a multi-scale feature descriptors and selection of inliers to refine the robustness of feature points.

Chen et al. (2015) proposed method to simultaneous registration and fusion of satellite image in a Unified Framework. It registers a high-resolution panchromatic image and a low-resolution multispectral.

Slomka et al. (2009) proposed software use for image registration in the medical domain and the facility to register images with an accuracy of 2 mm to 3 mm in rigid image registration of brain PET with CT and MRI.

Ayoub et al. (2008) proposed the influence of camera distortions on satellite image registration, change detection applications. It is a multi-temporal image registration approch which uses CNN

Falco et al. (2007) used differential Evolution for satellite image registration. Differential Evolution automatically registers multi-view and multi-temporal images implemented. It

is an iterative method to optimize problems.

4. Challenges

Researchers have contributed to the multimodal image registration domain, but it is an open challenge to develop an accurate, robust, and efficient solution in the view of following factors

1. Insufficient or unavailable satellite data image of different modalities. Very less comprehensive and complete database that contains different types of multimodal image pairs combined with their ground truths.

2. Intensity-based methods depend on the appropriate similarity metric, geometrical transformation method, and optimization. Intensity-based methods are difficult in the multimodal case due to the nonlinear intensity difference between images of different modalities. These methods are time-consuming in for high-resolution images and does not produce good result if image pairs undergo large deformations.

3. The core challenges in a feature-based are feature detection along with description. Multimodal images may contain different feature sets and lead to generalized image-matching tasks.

4. The deep learning framework has shown very good result for multimodal image registration, but it still have challenges with the data and other factors.

5. Each pair of image modalities differ from others due to the methods capturing, device, type of sensor image. It makes difficult to propose a universal image registration method for remote sensing.

5. Problem Definition

In this research, a novel multimodal registration method is proposed for environmental and agriculture applications. To build this, a combination of classical and modern image registration methodology is proposed for more accuracy. The proposed system uses the features of the source and moving images, intensity values, and deep learning algorithms for accuracy and robustness.

6. Objective

The main objective of the work will be to contribute novel approch for image registration of the different modality for the environmental and agriculture application.

1. To develop a novel algorithm by combination of feature-based and deep learning algorithm for multimodal image registration.

2. To develop a novel algorithm for multimodal images of different resolution.
3. To develop an self-regulating feature extraction against high resolution data using multimodality and deep learning technique.
4. To develop an automatic multimodal image registration

7. Future Research Plan

The objective of this research is to develop a multi-modality image registration method which is useful for environmental and agricultural applications. To achieve this, the following is planned:

1. Develop a multi-modal image registration method which will be able to register the image from a variety of sensors automatically for the environment and agriculture.
2. Design an algorithm that will use image metadata for decision-making for image transformations.
3. Enhancing feature-based, intensity-based, and deep learning methodologies for more accuracy.
4. Thesis writing.

8. Conclusion

Use of multimodality is increased due to extra information obtained from overlaying of the images. Although a number of algorithms have been proposed in this research area still there is room for improvement. Multimodality of images related to the environmental and agriculture domain is important for the analysis, prediction, and monitoring applications.

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